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Controller Gain-Tuning for a Small Spacecraft Attitude Tracking Maneuver Using a Genetic Algorithm

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Abstract

This article considers the problem of tuning control law gain parameters to optimize the performance of a small spacecraft in low Earth orbit (LEO). The control law under consideration has previously been shown to almost globally stabilize the attitude dynamics of a spacecraft under various operating conditions. In the present work the gain parameters are optimized offline for a small spacecraft performing a tracking maneuver in which the desired attitude is time-varying. The spacecraft is subject to both known actuator saturation limits and multiple external moments. Because of the complexity of both the control law and the problem under consideration, a genetic algorithm is used to optimize the gains of the controller. The genetic algorithm is designed to accommodate for actuator saturation constraints while still generating desired system performance by means of a user-defined fitness function. The controller designs selected by the genetic algorithm are compared to those found by tuning the gains manually using an "informed" trial-and-error search, and it is shown that the genetic algorithm-derived controller solutions generally yield better system performance. Furthermore, a preliminary investigation into the impact of spacecraft parameter variation indicates that the controller design selected by the genetic algorithm is robust to parameter uncertainty. This suggests that automated gain tuning by means of a genetic algorithm could substitute for a human engineer tuning gains in certain applications.

1. Introduction

The problem of tuning controller gain parameters to optimize the performance of a spacecraft in low Earth orbit (LEO) is of practical interest to the aerospace community. This paper focuses on the a priori tuning of gains for a recent small spacecraft science mission. In general, if the system to be controlled is linear or can be linearized about an operating point, then it is possible to apply classical root locus techniques for pole

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